Mycology

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QUARTERLY REVIEW

THE JOURNAL OF THE NATIONAL AGRICULTURAL ADVISORY SERVICE

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LONDON: HIS MAJESTY'S STATIONERY OFFICE: 1951

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ARTICLES

THE PRESENT POSITION IN THE BREEDING OF HERBAGE LEGUMES*

WATKIN WILLIAMS

Welsh Plant Breeding Station, Aberystwyth

The progress due to plant breeding in the last three decades or so has given to agriculture most of the strains of the traditional species of herbage legumes that it requires for efficient agricultural production. The most striking of these developments has been in the white clover species, where the pedigree big-leaved strains have brought about a radical change in both the production and utilization of the crop. A similar, though not nearly so spectacular, development has been the selection of the extra late-flowering type of red clover from local races in this country, whose special features remained undiscovered except to a small number of farmers until plant breeding was commenced on the species.

The experience gained in clover improvement during the last 30 years or so shows fairly clearly two important points. First of all, improvement has been effected only from ecotype populations which were already in existence, and which had reached a remarkable degree of natural stability both in type and performance. Secondly, when these natural ecotypes have subsequently been carefully multiplied, the ecotype has in most cases approached the pedigree material in the main important agronomic characters, and it has been difficult in many cases to show statistically significant differences between the natural ecotype and the bred strains.

The fact that strains produced by relatively simple methods can be serious rivals to pedigree selections raises fundamental breeding problems, and provokes some consideration of our present-day approach to selection and breeding. It is important to realize what is involved in such a situation, and to examine anew the methods used in the improvement of these crops. The experiments done on maize selection prior to the introduction of hybrid maize, as well as the results of testing selections of herbage plants against the population from which selection was made, indicate that there are definite limitations to the degree of improvement that can be effected.

Limitations on Degree of Improvement

It appears that, where the breeder is selecting a character in the same direction as the natural selective forces have been operating, with our present methods of strain building (and they are the only ones available to us at the moment), little or no effective increase in

*Reprinted from *The Annals of Applied Biology*, **37**, No. 2, June, 1950, by courtesy of the Editor.

the expression of that character can be made. In other words, if a selection is made from a population, and the main type of the original population is retained, it is unlikely that a significant improvement can be effected. If, on the other hand, the selection is for a type which comes at either end of the population curve, say at outside $\pm 3\sigma$, it is then possible that an improvement in some agronomic feature can be achieved, but the product will be entirely different from the original population, and will demand a new and different place in agriculture by reason of the particular environmental requirements of its genetic make-up.

Consider the extra late-flowering population of red clover, such as Montgomery red clover. If, on the basis of density and date of flowering, selection is made within $\pm 3\sigma$, a more uniform population of plants is obtained whose mean yield in a pasture is only slightly above (if at all) that of the parent population. If one selects below -3σ, one may isolate a late form resembling a type already in cultivation, or again if selection is above $+3\sigma$, a very dense and very late form of red clover is derived, which is of doubtful value in agriculture owing to its late vegetative and floral development.

Such a situation may be peculiar to pasture plants and some others which are influenced greatly by inter- and intra-specific competition both in the natural and cultivated state, and it may seem strange that selection within the upper limits of the curve of a naturally selected population does not produce significant increases in yield. The reason for this may be the severe competition which takes place among pasture plants and the high selection pressure resulting from such competition. In a population variable for vigour and yield, only the most aggressive, and therefore the most productive, are able to establish and produce seed under the given circumstances. There is therefore a very rapid elimination of the inferior genotypes, especially in cultivated strains, with the result that a strain which has been selected naturally or semi-naturally through conscious human mass-selection, can be expected to express the yield factor practically at its maximum. In view of this, selection, even when this is supported by progeny testing, can effect little improvement.

All the above needs to be qualified in two important respects. First, the remarks apply only where no severe limitations to yield expression (such as susceptibility to disease) are present; and secondly, they can be applied to breeding procedures only where relatively large numbers of extremely heterozygous plants are used for breeding. As far as I know, no one has yet shown the minimum number of plants that can safely be used for strain building in the various cross-fertilized crops. Further yield increases can possibly be expected if the number of basic plants can be reduced to six, or better still to four, when one can make reasonably certain of securing good combinations of plants whose progeny performance is appreciably above the general average of the population. Where the number of basic plants is high, a few of the introductions are usually well below the best in "combining ability," and serve to lower the mean value of the strain and thereby bring it near to the average of the population.

A still greater effect on the yield factor might result if hybrid seed, or seed only one or two generations advanced from the hybrid, could be made available to the farmer. There are immense practical difficulties in accomplishing this, and the increases would have to be really substantial (of the order of 20 per cent or perhaps more) before such hybrid seed could be economically bought. The possibility is worth exploring, especially since the sterility factors in the *Trifolium* species make it relatively easy to produce intra-sterile families, at least on an experimental scale, which could be used for hybrid seed production.

Considerable improvement in yield might also result from the production of artificial polyploids. Swedish workers have obtained promising results from colchicine-induced polyploidy in some *Trifolium* species—notably *T. hybridum*. It is important to explore possibilities in this field with other of the important legumes, but it appears, on the evidence already available, that the species with low chromosome numbers present the most promising material on which to make a beginning.

Breeding for Disease Resistance

Breeding for disease resistance in herbage legumes is of major importance only in the red clover species, where widespread damage is caused by *Sclerotinia trifoliorum* and the clover stem eelworm *Ditylenchus dipsaci*. Certain strains are already available which show some field resistance to these diseases, but unfortunately they are not of the agronomic type which is required on the 1-year ley lands where the diseases are most serious. An early double-cut type will have to be found to combat these diseases. Work on breeding for resistance has been in progress in several countries for many years, but no types possessing immunity have been found. Selection has been practised mainly under field conditions. This method proved very unsatisfactory because of severe fluctuations in the incidence of field infection, and recently laboratory methods of infection with the *Sclerotinia* disease have been developed. It is not yet known whether resistance can be achieved. It is significant that in spite of many attempts in various institutions in Europe, no genotype showing clear-cut resistance has been found in red clover. This may mean that the genes for resistance are absent in the central and north European cultivated clovers, and that collections of plants from the Mediterranean region—the believed gene-centre of the genus—will have to be made before the desired genotypes are found.

A problem which has received surprisingly little attention in a highly developed agricultural country like our own is that of the authentication of agricultural seed. The development of multiplicity of strains within a species, which differ only in agronomic performance, has made the problem of authentication of clover strains almost impossible even to the specialist. The opportunities offered for genuine mistaken identity are a serious limitation to the full use of improved strains, and therefore to maximum production. The selection of marker

recessive genes is a possibility and in the two *Trifolium* species the leaf mark gene has proved a convenient marker. One strain of white clover breeding true for the absence of the leaf mark has been developed and is now in the final stages of testing in agro-biotic trials. Breeding for authentication is one of the most immediate and tangible contributions that can be made by plant breeding in this field.

Problems of Seed Setting

Apart from authentication and resistance to disease, the problem of seed setting in legumes is among the most urgent, and its solution is not so easy to find. Improved seed setting in red clover and lucerne is being sought by plant breeders in most of the countries of the Northern Hemisphere, excepting those with a near Mediterranean type of climate. The potential seed production is good, but in practice, good crops can be obtained only in about one season in five. With lucerne the proportion of good seed crops is even less. The chief insect pollinators are members of the *Bombus* genus, although the honey-bee can and does, under certain circumstances, pollinate red clover.

For maximum pollination by honey-bees the difficulty appears to be the length of the corolla tube, making nectar collection difficult for the short-proboscis type of insect. Efforts to increase seed-production capacity of red clover by shortening the corolla tube have not proved entirely encouraging. The Czechoslovak strain " Zofka " with its shorter corolla tube has not proved in trials in America to give substantially heavier seed yields than the longer corolla tube types. It is only when conditions are favourable and other sources of food are scarce, that hive-bees will visit the red clover crop, and certain forms of bee management are showing indications of greater promise than breeding. So very little is known, however, about the bee-flower relationship that it would be unwise to say that breeding cannot contribute towards a higher seed-set. It may be that breeding for a greater flow of nectar, as well as nectar of a higher sugar concentration, may assist in making a short corolla-tube type of red clover a suitable plant for pollination by the hive-bee. The immediate remedies, as far as red clover (and indeed lucerne) is concerned, lie outside the scope of breeding. They are : (1) the concentration of seed production in the areas of lowest rainfall, and (2) the preservation and if possible the fostering of the *Bombus* populations, which are undoubtedly suffering because of extended cultivation and probably also owing to the extensive use of the newer insecticides with their long-lasting effects.

Seed setting in lucerne presents a somewhat different problem in that the difficulty seems to be the high tension within the florets, which, in a relatively cold moist environment, prevents the tripping of the floret except by the very heaviest insect species. Swedish workers are trying to solve this problem by crossing *Medicago sativa* and *M. falcata*, but such hybrids of this cross as have been under observation at Aberystwyth have not shown any greater seed-setting capacity. The answer to this problem may be in a non-tripping type

of plant with an open keel, which would allow of easy visitation by all insects and ensure pollination. The only objection to the non-tripping types would be in their greater tendency to inbreed and thereby reduce vigour. This possibility has influenced several workers against changing the tripping mechanism. The evidence with most crops seems to suggest, however, that pollen-tube competition reduces inbreeding tremendously in such instances, and on the basis of the former argument in connection with the likely establishment of only the vigorous types in these pasture species, a proportion of 70 per cent or even less of hybrids from these non-tripping types would ensure a full stand. The ideal, which is by no means impossible to achieve, would be fully self-sterile but non-tripping parent plants.

Another desideratum with lucerne is to breed a type suitable for the higher rainfall and more acid regions of the country, and in this connection the cross between *M. falcata* and *M. sativa* does seem to offer possibilities. For the better soil types of this country, and for the drier regions, it appears that it will take a great deal of effort to effect even small improvements in performance on the strains already available. It is our good fortune that no serious disease of lucerne exists in this country.

Breeding for Chemical Quality

Finally, there is a fairly recent problem in legume breeding which involves the breeding for absence of principles liable to cause physiologic disorders in animals. Some of these diseases are as old as the history of agriculture, but with the recent strides towards intensive production they have become more prominent. The most familiar one is " bloat " in farm animals, which may involve a physical inability to get rid of waste gasses from the rumen, due to congestion, or a paralytic effect on the muscles of the rumen. The second type—the paralysis of the intestine—has been produced experimentally by two groups of workers in this country by using clover juice extracts on the small intestine of a rabbit. It has been suggested that prussic acid produced by the cyanogenetic glucoside may be a contributory cause ; also a flavone compound has been identified as capable of producing the same effect. Whatever may be the real cause of this important physiologic disorder, it does seem that the problem may be effectively tackled by plant breeders and biochemists working as a team. This whole field of breeding for chemical quality is one which we shall hear a great deal more about in the future—not only in legumes—but also in other crops.

The problems of legume breeding are no longer of the straightforward type, where something spectacular can be achieved by mere selection. As far as one can see, few, if any, new and distinctive types of clover strains are probable. On the other hand, several refinements are necessary, and these can be affected only after the desired genotypes have been found, and after the specific genes have been introduced into selections from the cultivated strains. In this way, improvements in resistance to diseases, in increased seed setting, and in the biochemical nature of the strains, can be accomplished.

CANADIAN EXPERIMENTAL FARMS

JOHN ANDERSON

Provincial Director, N.A.A.S. Eastern Province

The origin of the Experimental Farms Service which today spreads its network over the length and breadth of the Dominion, lies back in 1885 when the then Minister of Agriculture invited Dr. William Saunders, later the first Director of the Service, to visit the Experimental Farms in the United States, and to make recommendations.

His report became the basis of the Experimental Farm Station Act of 1886 which outlines the functions of the Service as assisting " the promotion of Agriculture by the dissemination of useful and practical information respecting matters connected therewith ". Under this Act, five Experimental Farms were established, one at Ottawa, the headquarters of the Service, to serve Ontario and Quebec (this later was designated the Central Farm), one at Nappan, Nova Scotia, for the Maritime Provinces, one at Indian Head for the North West Territories, one at Brandon for the Province of Manitoba, and the last at Agassiz to serve British Columbia. It has become the practice to reserve the title of Dominion Experimental Farm for the five original stations set up under the Act, subsequent establishments being known as Dominion Experimental Stations or Sub-stations, depending on the magnitude of the undertaking.

The main lines of investigation to be undertaken at the Experimental Farms were outlined in the Act, and specified livestock breeding, dairying, the development and testing of new varieties of field crops, grasses, forage plants and vegetables and the study of fertilizers, diseases and pests.

The original plan of the Experimental Farms Service provided that general research should be conducted at the Central Farm by officers specializing in the appropriate branches of agriculture, whilst experiments and demonstrations applicable to the various farming regions would be carried out by the superintendents of the remaining Farms. Both specialists and superintendents were on the staff of the Director of the Service. So well conceived were these original plans that, despite the passage of more than sixty years, the essential features remain unchanged, though the Experimental Farms Service has expanded to keep pace with the development of Canadian agriculture, and today covers, besides the Central Farm, 28 branch farms with attendant sub-stations and laboratories. Close upon 24,000 acres are now owned by the Service and, in addition, more than 26,000 acres, principally of range land, are leased.

Illustration Stations

Midway between the Experimental Farm and the man on the land comes an interesting group of farms owned by men prepared to co-operate with the scientist in the demonstration of the results of his researches. These Illustration Stations as they are called, are,

in effect, sub-stations which are operated by the farmer under agreement with the Dominion Department for the minimum period of three years. These stations permit the further observation and testing of various practices under a wider variety of soil and climatic conditions than is possible on the Experimental Farms alone, and whilst they may be more suitable for teaching broad principles than details, they provide a most effective means of bringing the practical character of the recommendations to the notice of the neighbouring farmers with the least possible delay. These small units form effective outposts of the Service, taking the results of the centrally organized experiments to the doorstep of those who will benefit from utilizing the new and improved practices. Field Days are held from time to time, usually organized in co-operation with an Agricultural Representative and one or other of the local farming associations or societies. On these occasions details concerning the soil preparations, fertilizer treatment, selection of varieties and growing of crops appropriate to the locality, are demonstrated and discussed by officers of the Experimental Farms Service. That these Field Days are appreciated is borne out by an analysis of the records which show that these events are annually attended by more than 25,000 farmers.

Organization of Research

The work of research at the Central Farm at Ottawa, originally conducted by a small number of specialists, is now the responsibility of the Director. He is the general administrator, and has ten divisions each under the control of a Divisional Chief with staff specializing in Animal Husbandry, Bees, Cereals, Field Husbandry (which includes Agricultural Machinery), Flax Production, Forage Plants, Horticulture, Illustration Stations, Poultry and Tobacco.

Agricultural problems, wherever they may originate, are kept under constant review by the specialists of the divisions, and experimental projects are drawn up for work to be undertaken either at Ottawa, or at whichever of the Branch Farms is best suited from climatic and soil aspects to contribute most to the solution of the problem. In many cases the tempo of the work of research can be speeded up by the replication of the experiment simultaneously on a number of the Branch Farms with the object of determining the effect of climatic conditions upon cultural practices or treatments, or in quickly establishing the geographical ranges suitable to certain varieties of crops or classes of livestock. The wide network of Experimental Farms offers further advantages in making it possible to focus the scientific interest of other Government Departments, of the National Research Council and of Provincial Universities in all parts of the Dominion, on the solution of local agricultural problems.

It is impossible to do justice to the fine work which is proceeding at each of the Experimental Farms in the Dominion Service within the limited scope of an article of this kind, but the following brief survey may serve to indicate the breadth of the research field being covered by some of the Divisions.

Animal Husbandry Division

The work of this division covers systematic research into the breeding, feeding, housing and management of all types of livestock. On the Farms can be seen representatives of practically every breed suitable to the varied climatic conditions found within the Dominion. Breed comparisons of cattle are being made from standpoints of economy of production as well as suitability, and one of the principle lines of research on beef cattle is directed to the development of a single type of Shorthorn which, in combining good beef qualities and reasonably high milk production, will make it attractive over a wide area of the Dominion. At Manyberries, Alberta, research breeding projects concern the improvement of Hereford cattle for range conditions ; in this connection the quality and carrying capacity of rangeland pasture naturally play an important part. The results of the grazing experiments carried out at this station indicate 20 acres per head for the summer grazing season are insufficient, and that yearling heifers will lose weight at this low density of stocking. It is clear that the term " grassland " can have many shades of meaning.

A long-term hybridizing project at Buffalo Park, Wainwright, aims to produce a cross which will combine the hardiness of the buffalo with the meat producing qualities of domestic cattle. Whilst progress is being made in the production of the new Cattalo hybrid, it will be some years before the project has commercial possibilities.

In common with the principal sheep producing areas of the world, Canadian statistics showed a declining population of this class of livestock in the early post-war years. Recent improvements in mutton and wool prices have given a fillip to the breeding studies directed towards evolving a suitable crossbreed for western conditions where the anticipated expansion in flocks is likely to take place. The Romnelet, a product of crossing Romney Marsh rams with Rambouillet ewes gives promise of fulfilling the purpose in view.

The evaluation of breeds of pigs for bacon production has clearly put the Yorkshire breed in a position of undoubted supremacy, and farrowing records kept at Lacombe for the years 1925-42 reveal that average litter sizes are in excess of 12. In a country where temperatures are likely to fall substantially below zero in winter, the heating of piggeries has been made a matter of intensive study, and many interesting means of producing and conserving heat—the use of natural gas for instance—are to be found. Moisture condensation can be a great problem in this connection.

Cereal Division

The principal function of the division is to obtain the most profitable varieties of cereals, peas, field beans, flax and buckwheat for use in all parts of the Dominion, and on practically all of the Branch Farms there is in progress an intensive programme of selection of hybrids produced on the Central Farm at Ottawa, for the purpose of determining the most suitable varieties for the region covered by the Farm. One valuable piece of work is the development at Swift Current of

strains of wheat having a solid stem which is materially reducing the damage caused by the wheat stem sawfly, a troublesome pest in the Dominion.

Probably the most important work now proceeding under the aegis of the Cereal Division is that being carried out at the Rust Research Laboratory at Winnipeg where the task of producing new rust-resistant varieties of wheat is concentrated.

Field Husbandry Division

In securing reliable information on the most profitable methods of crop production under the various climatic, soil and marketing conditions, this division conducts extensive investigations into the cropping, cultural and farm management practices on most of the Branch Farms throughout the Dominion.

The Soil Surveys, organized on a co-operative basis between the Dominion and Provincial Departments of Agriculture and the Agricultural Colleges, are rightly forming the starting point of many research projects, and one cannot help but be greatly envious of the state of completeness of the survey work in many of the Provinces.

Profitable crop production on the vast area of the Prairie Provinces depends, to a very large extent, on the preservation and economical use of the limited precipitation of rain and snow. The Field Husbandry Division has, for twenty-five years, conducted a series of experiments at Swift Current, Sask. to determine the relationship between soil moisture and crop growth. The result of this work shows that in south-western Saskatchewan, on the average, crops after fallow obtain some 45 per cent of their total water requirements from moisture already in the soil at seeding time ; the corresponding figure for crops following stubble is only about 25 per cent. Experiments are in hand throughout the Province in order to learn the best methods of conserving moisture, and these include summer fallowing methods, contour furrowing, stubble mulching and terracing.

Forage Plants Division

Particular attention is given by this division to the improvement of forage crops in the Dominion by the improvement of existing species of grasses and leguminous plants, by introducing new species from foreign sources, by variety tests and by hybridizing and selection to produce new species. Other activities concern the technique of seed production, pasture and range studies.

The alfalfa improvement programme is being conducted with two main objectives in mind, the production of varieties which are resistant to Wilt and Crown Rot—since these two diseases are causing very serious losses in second year stands in Western Canada—and the production of hay and pasture types which will stand up to heavy grazing under dry conditions.

Breeding projects for the production of a creeping type of alfalfa are in progress at St. Anne de la Pocatiere, Quebec, Ottawa and Saskatoon. The low-crowned Siberian variety with its creeping root

system has been crossed with Grimm and Ladak varieties to produce a hybrid of very persistent type, combined with a desirable degree of winter hardiness.

New areas for maize production have developed in various parts of Canada as a result of the production of new commercial hybrids at the Dominion station at Morden, Man., and of the extensive performance trials conducted at Harrow and Ottawa. This testing programme is closely followed by growers who gather information and guidance which enables them to select, with confidence, those hybrids which are particularly suited to their local conditions.

Division of Horticulture

Horticultural work is carried on at all Branch Farms but at many of them it consists of variety testing and minor cultural experiments only. The main endeavour in the field of horticultural research work is carried out at the Central Farm, but special projects are being studied at Kentville, N.S., Fredericton, N.B., Morden, Man., and at Summerland, Agassiz and Saanichton in British Columbia.

From the very early days the breeding of fruit, and especially of hardy apples, has been one of the principal features of the work of this division, and such outstanding varieties as Melba, Lobo, Atlas and Joyce are testimonials to the high skill of the Dominion breeders. It is interesting to observe that Malling II rootstocks are recommended for their resistance to the Crown-gall organism, and that Malling IX has been found particularly suitable for the orcharding practice on Vancouver Island, where it produces small dwarf trees that come into bearing within two to three years after planting.

On the vegetable side no praise is too high to associate with the potato breeding work carried out at Fredericton, where the production of seedlings resistant to late Blight, common Scab, virus diseases and aphids is the principal feature. The tests are conducted in twenty-four localities across Canada and show clearly that in order to assess with accuracy the value of a particular seedling, it is necessary to test it over a wide area for it may show a high degree of resistance to late Blight or Scab in one Province, and extreme susceptibility in another.

Poultry Division

The work of this division, both at Ottawa and on the Branch Farms, becomes increasingly more of a research character as the industry improves in technical status. The principal fields of work concern breeding, nutrition, housing, management and disease control applied to chickens, turkeys, and waterfowl.

An interesting experiment is proceeding at Saanichton, B.C., with the Station's single comb White Leghorn breeding flock. In addition to the usual basis of selecting the female line—good egg production, low mortality, high egg weight, good conformation and so on—special attention has been given to the selection of individual birds with regard to eye-colour and condition. In the better birds the pupil is bright, clear and perfectly round with a reddish or bay pupil, whereas second

grade birds show considerable variation in colour with much blurring of the pupil.

The summary of the past five years' work shows a pullet mortality in the normal eye group of 6.5 per cent, as against 21.4 per cent in the group showing abnormal eye condition. The egg production figures are 231 and 201 eggs per bird respectively. From these significant figures it is apparent that the selection of pullets at sexual maturity on this basis could produce a very large economic saving to poultry keepers. A major breeding project has been drawn up at this station with the objective of determining the degree of hereditability of this eye deformity, and the most satisfactory means of reducing it.

Among environmental factors affecting the performance of poultry in the Dominion, housing is particularly important because of the rigorous winter conditions which prevail in most parts of Canada. The best types of poultry house, and the most efficient system of ventilation and insulation, are receiving constant attention from research workers throughout the Experimental Farms system.

Because of the growing economic importance of turkeys, an extensive programme of research into rearing problems proceeds at the Central Farm; comparisons of the most suitable breeds, the control of blackhead, feeding and management are all subjects of research projects.

METEOROLOGY AND AGRICULTURE

POST OFFICE GUIDE STATIONS

N.A.A.S. Quarterly Review No. 11. Page 107

Certain amendments have been made in the telephone extensions shown on the map, from which weather forecasts can be supplied to members of the public. The correct details for the stations concerned are now as follows :

Station	*Telephone numbers*
Aberdeen (Dyce)	Dyce 331, Ex. 20.
Bawtry	Bawtry 363-7, Ex. 56, 105.
Gloucester	Gloucester 24465-7, Ex. 110, 111.
Mildenhall	Mildenhall* 2281, Ex. 16, 17.
Liverpool (Speke)	Garston 1240, Ex. 21, 22.
Preston	Preston 4602, Ex. 203, 204.
Renfrew...	Renfrew 2352, Ex. 21, 23.
Southampton (Eastleigh) ...	Eastleigh 87228-9, Ex. 8, 10.

*Note new Exchange

ABSTRACTS

ANIMAL BREEDING

Estimation of Genetic Gain in Milk Yield by Selection in a Closed Herd of Dairy Cattle. RENDEL, J. M., and ROBERTSON, A. *J. Genet.*, **50**, 1-8.

The simplest and most direct way of breeding farm animals is by mass selection, that is, by choosing breeding stock purely on the basis of their own phenotype and mating the chosen animals at random. In dairy cattle the value of this practice is reduced, since such selection cannot be practised on males. It is therefore suggested that the bull should be judged on the performance of his progeny in order to make up for the fact that he has no measurable phenotype himself.

This paper examines the method of mass selection, firstly from the theoretical point of view, and then from the practical aspect, considering how much selection is practised in herds and how much the yields can be increased by genetic improvement.

The variation in the average yield of a herd gives little indication of the genetic improvement achieved; the increase shown may be due entirely to changes in management.

The difference between the inherited yields of the daughters of two cows is, on the average, only one quarter of the difference between the records of the cows themselves.

The genetic rate of improvement was calculated by the writers from records of a herd started in 1903 and which is still in existence. Although some breeding stock has been purchased, about two-thirds of the animals born up to 1933 were sired by home-bred bulls. Thus it is possible to calculate the selection actually practised, both in breeding cows and bulls.

The findings from the investigation suggest that the maximum possible rate of genetic improvement in a closed herd would seem to be about 1 per cent of the average yield in a year. This rate of improvement depends on the length of the generation, which in the herd in question was just over three years. An examination of the Shorthorn and Friesian herd books shows that the average length of a generation is over four-and-a-half years, so this would reduce the maximum genetic gain to 0.6 per cent per year.

Most herds are not closed, in that bulls are brought in, and this would tend to reduce the genetic improvement expected, as the management factor is less well known. Selection for other factors, such as type and butterfat percentage, will also tend to reduce yield improvement.

Practically all the improvement expected comes from the selection of the dams of the bulls. Only one quarter comes from the selection of the dams of the cows. The contribution of the cows would be

improved by anything which would increase the average number of heifer calves born in the lifetime of a cow.

It is often argued that selection for productivity alone is liable to decrease the vigour and longevity of the animals produced. The evidence at present available is that there is some such negative relationship between yield and longevity, although this is very small ; in addition to which, cows are naturally selected for longevity, in that high producers are usually kept in the herd as long as possible.

The use of artificial insemination in connection with progeny testing is likely to increase the rate of genetic improvement which may be expected.

Grazing Habits of Dairy Cows in New Zealand. Hancock, J. *Emp. J. exp. Agric.*, 1950, **18**, 249-63.

There are some interesting hereditary factors brought out in this study of grazing behaviour in New Zealand.

Monozygotic cattle twins were used in all the trials and these proved to be many times more efficient than the usual random selection from a herd of cows. It also made it possible to measure the influence of heredity on grazing behaviour.

Twin pairs showed great similarity in their method of grazing, a pointer that such characteristics are inherited. Their speed of grazing, selectivity in grazing and the ratio of ruminating time to grazing time were about equal. Other factors such as the number of drinks taken, the number of evacuations and micturations, the number of bites to each bolus and the average length of rumination periods were also very similar. Inherited individuality influenced the distance walked by the cow when at pasture and this was more or less relative to the amount grazed.

Both numbers of the set occupied strictly the same bunting order (fighting) ; fighting between twins occurred only in one pair and always ended in a draw, a situation which has not been observed in non-twins.

Though this communication deals chiefly with grazing habits, it was thought that the inherited characters portrayed by the cattle might be of interest.

W.L.

ANIMAL NUTRITION

Phosphorus

This element is very important in nutrition because it is concerned with the metabolism of protein, carbohydrate and fat as well as of bone, and thus it is not surprising that at least a quarter of the body's phosphorus is in soft tissues. Calcium, on the other hand, is almost entirely in bone, only about 1 or 2 per cent of the total being in blood and other soft tissues. Deficiency of phosphorus is thus more likely to make itself felt than deficiency of calcium, and, since phosphorus-rich concentrates are scarcer than they used to be and pastures are sometimes poor in

phosphorus, dietary deficiency of this element is an ever-present possibility.

Reports of aphosphorosis (phosphorus deficiency) are appearing more and more frequently, and three recent typical instances are those recorded from the Mid-Counties of Ireland by Sheehy and his co-workers[1], from Western Australia by Snook[2], and from East Anglia by Ewer and Sellers[3]. Symptoms attributed to this condition include enlargement of joints, with which is associated stiffness of gait and unwillingness to move; slow growth, and a tucked-up, miserable appearance, with a staring coat; long periods of temporary sterility, resulting in a poor calf crop and loss of milk; low milk production; reduced appetite; chewing of sticks, stones, bones, rags, etc.; and low blood phosphate, sometimes less than half the normal value. It is pointed out that even where gross symptoms are not present, there may be unsuspected loss from milk yields being lower than the potential, from longer intervals between calving, and from slower growth rates.

The requirement of the lamb for phosphorus has been estimated by Beeson[4] and by Gallup[5] to be 2.0g. P(4.5g. P_2O_5) as a minimum, or 2.4g. P(5.5g. P_2O_5) as an optimum, per 100 lb. live weight. On the basis of the standards set by the National Research Council of the U.S.A., a cow weighing 10 cwt. would require 11g. P(25g. P_2O_5) daily for maintenance, and each gallon of milk would require 7g. P(16g. P_2O_5). From this it may be calculated that many pastures are capable of providing for only a very low milk yield in addition to maintenance, and a normal or heavy yield will cause considerable drainage of phosphorus from the body and may interfere with some of the other functions which phosphorus has to perform.

Several ways of meeting this can be suggested, e.g., the application of phosphatic manures to the land; or, for more immediate results, the feeding of concentrates containing bone, or the giving of a little sterilized bone flour (2 oz. daily) or its equivalent in other forms of phosphate, or the feeding of proprietary mineral mixtures. Snook[2] has suggested that if bone products are difficult to obtain, it might be possible to utilize superphosphate. If 5 lb. of 18 per cent superphosphate is added to a gallon of water and the soluble phosphate is completely extracted by frequent stirring and pouring back and forth, then the clear liquid, obtained after the sludge has completely settled, contains 4 per cent of P(9 per cent of P_2O_5) [6]. The sludge which contains the insoluble calcium compounds, including the harmful fluoride, is thrown on the manure heap. The clear liquid may be used to sprinkle on the feeding-stuffs, or it may be added to drinking water at the rate of one part to 250 parts of water.

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S.M.B.

Pre-partum Milking

The subject of pre-partum milking, or milking before calving, is one of the most controversial in the dairy husbandry field. Argument for and against the system usually concerns (*a*) the health and well-being of the cow; (*b*) the output of milk or butter fat; and (*c*) the nutrition of the calf born subsequent to the pre-partum milking.

So far as the first two aspects are concerned, little extensive and reliable evidence has, so far, been published, and in view of the enormous variations in yield and health between one cow and another, very large-scale investigations would have to be undertaken to provide reliable evidence on these points.

One investigation at the University of Connecticut, in which 43 cows were used, showed that certain important blood constituents were not significantly affected at calving by milking 10 days before calving. (Eaton *et al. J. Dairy Sci.*, 1949, **32,** 870). This evidence is quoted by Hill, Widdowson and Maggs (*Agriculture*, 1950, **57,** 351-8) in support of their own finding that pre-milking was not strongly correlated with the incidence of milk fever. Advocates of pre-partum milking sometimes press the advantage of the system to relieve udder congestion. Workers at Michigan (Meites, Horwood, Reincke, Bryan and Smiley, *J. Dairy Sci.*, 1950, **33,** 383) believe that the congestion is caused primarily by a lymphatic and venous stasis and not by filling of the udder with milk. They were able to demonstrate that the congestion could be substantially reduced by massaging the udder with an oil containing the hormone diethylstilboestrol.

There has been a number of recent publications on the effect of pre-partum milking on the composition of the fluid obtained from the udder after calving. Eaton, Johnson, Spielman, Matterson and Hezvesky (*J. Dairy Sci.*, 1949, **32,** 919 and 1032) were able to show that pre-partum milking decreased the carotene and increased the lactose content for six milkings after calving. They also showed that the level of blood plasma carotene and vitamin A in the calves born from cows milked pre-partum and fed their dam's colostrum and milk, were at significantly lower levels than similar calves from cows not milked pre-partum. The practical significance so far as the health of the calf is concerned, is difficult to assess, due partly to great variations in vitamin A and carotene content of colostrum from breed to breed, country to country, etc. For example, workers in India (Paul, Kalyanakrishnan, Lazarus, Anantakrishnan and Sen, *Ind. J. Dairy Sci.*, 1950, **3,** 112) in studies of the effect of pre-milking on the composition of colostrum and milk, found a much higher vitamin A content in butter fat than the workers at Michigan, irrespective of pre-partum milking. At the conclusion of a report of a study in this country, Hill *et al* (*Agriculture*, 1950, **57,** 351-8) conclude that pre-milking may be carried out without detriment to the calf or its dam. While this may apply generally, it is perhaps wise, pending further studies, to remember that under some circumstances the dam and the calf may be so near a

particular nutritional threshold that the difference between pre-partum milking and no pre-partum milking may be of significance.

Feeding Standards

K. L. Blaxter, in an excellent review on Energy Feeding Standards for Dairy Cattle (*Nutrition Abstracts and Reviews*, **20,** July 1950), attempts to appraise the reliability of existing feeding standards. In the first part of the review he discusses the vital factors affecting the energy requirements of dairy animals which form the background of the feeding standards. The requirements of the foetus, those for post-natal growth and development, for maintenance, lactation and fattening are critically discussed in the light of the established facts reported in the literature. Factors influencing these requirements are also analysed. The various feeding standards used throughout the world are then described, analysed and compared, after applying relevant corrections. The last chapter deals with methods of feed evaluation and the energy value of feeds in relation to the energy feeding standards. This review stresses the need for application of feeding standards, but also points to their limitations and shortcomings.

A.S.F.

DAIRY BACTERIOLOGY

Colony Counts on Strips of Agar in Tubes

The cost of petri dishes and the necessary media is a formidable item in laboratory expenditure, and methods making for economy must be welcomed. Stirling, Stevens and Lawley (*J. Gen. Microbiol.*, 150, **4,** 339) describe such a method. For counting viable bacteria, 0.1 ml. of the bacterial suspension is mixed with 1.5 to 2 ml. of nutrient agar and allowed to set in an almost horizontal tube to produce an agar strip 3-4 in. long. The tubes incubated in the vertical position yielded counts not significantly different from those obtained with plates inoculated with 1 ml. of the suspension.

Colony Illuminator

In the same journal a new colony illuminator embodying a fluorescent ring tube for side illumination is described (p. 448) by Moore and Taylor.

Udder Infections in the Dry Period

Neave, Dodd and Henriques (*J. Dairy Res.*, 1950, **17,** 37) describe detailed studies, over a long period, on udder infections occurring during the dry period of milch cows.

It is possible that the method of drying-off has an important influence upon infections of the udder, but there is little information on the numbers, types and duration of these infections and their effects on the yield of milk in the subsequent lactation.

In the years 1946-48 the average number of cows in the herd in each week of the year was 45.4, 49.8 and 47.7 respectively, and the corresponding lactation ages 2.75, 2.48 and 2.34. *Streptococcus agalactiae* infections in these years were 16, 11 and 5, infections with other streptococci 7, 10 and 12, and infections with staphylococci 6, 19 and 25.

The dry-period infections of 94 cows were investigated. In 75 cases there were no infections before drying off but 19 cows had an infection in one or more quarters at that time. In the 94 dry periods investigated new infections occurred in 48 per cent of cases. Half of these infections persisted in the next lactation, and of these about one half became clinical.

Most of the dry period infections were caused by *Str. dysgalactiae*, *Str. uberis* and by Staphylococci—few were due to *Str. agalactiae*. Staphylococcus infections were much more persistent than those caused by *Str. dysgalactiae* and *Str. uberis*. *Str. agalactiae* infections were also more persistent. The new infection rate was very high during the first 21 days of the dry period.

Keeping Quality and Raw Milk Grading. II. Effect of Storage on the Results of Keeping Quality and Dye Tests.

This paper, by Eddison, Kempthorne, Hosking, Barkworth, Cox and Rowlands (*J. Dairy Res.*, 1951, **18,** 43) follows that under the same general title which was abstracted in No. 10 of the Review. In this country it is usual to store milk samples for a prescribed period of time before tests are applied, and the experiments analysed in this paper were designed to assess the effect of pre-test storage on the results obtained by various tests for keeping quality. A practical method of compensating test results so as to eliminate their dependence upon the time and temperature of pre-test storage was also sought.

Sub-samples of morning milk from several areas in England and Wales, brought to the laboratories without delay, were stored at temperatures ranging from 3-24°C. and at shade atmospheric temperature for periods varying from 7 to 30 hrs., before being examined by several tests for keeping quality : C.O.B. (Clot-on-boiling) test after storage at 18°, 22° and 24°C. ; precipitation with 68 per cent alcohol ; Methylene blue reduction test at 37.5°, 24°, 22° and 18°C.

The curves drawn from the data obtained for keeping quality were found to be roughly parallel, and there was good differentiation between samples with all pre-test storage temperatures.

Temperature compensation may therefore be applied to keeping quality results which means that results to be expected after storage at one temperature may be calculated from the results after storage at another temperature. On the other hand, the curves for methylene

blue reduction at 37.5°C. converged sharply after storage at the higher temperatures (above). Thus, after storage at 22°C., almost identical results were secured with samples giving widely different results after storage at lower temperatures.

After storage for 22 hours it is not possible to apply temperature compensation to the results of the methylene blue test at 37.5°C. It may, however, be possible so to compensate results secured after a shorter period, say 8 hours of pre-test storage.

A formula for relating C.O.B. times to various temperatures was derived from the data and an example is given of its use with alcohol precipitation time (A.P.T.) and C.O.B. for calculating the time to end-point of a sample after incubation at any temperature from the time to end-point of the same sample after incubation at a given temperature.

Some Bacteriological Aspects of the Deterioration of Pasteurized Milk

Ashton (*J. Dairy Res.*, 1950, **17,** 261), has, in careful experiments, re-examined the relative efficiencies of "Holder" and H.T.S.T. pasteurized milk. The examinations were made on samples of milk from one and the same raw bulk after "Holder" pasteurization in the laboratory and H.T.S.T. pasteurization in a standard commercial apparatus, respectively.

Colony counts and coliform tests were made when the samples were fresh and after storage at 18°C. for 24 and 48 hours. Methylene blue and resazurin reduction tests were also made on the fresh samples and after ageing at 18°C. for 45½ hours. Finally, C.O.B. (Clot-on-boiling) and 68 per cent alcohol tests were observed to end-points.

The bacteriological and dye reduction tests were carried out at 37°, 30° and 22°C. It was found that a higher percentage of organisms survived in the H.T.S.T. than in the "Holder" pasteurized milk, but the keeping quality of the latter (after-contamination being avoided in all cases) was inferior to that of the H.T.S.T. pasteurized milk.

These results suggested fundamental differences in the effects of the two processes which affected the behaviour of milk aged at 18°C. Peptonizing organisms, in the absence of after-contamination, were the major cause of deterioration.

The flora of the H.T.S.T. pasteurized milk was more varied, and during ageing growth of the organisms proceeded steadily. With "Holder" pasteurized milk, growth was retarded during the first 24 hours at 18°C., but later peptonizing organisms grew rapidly and affected the keeping quality significantly.

Methylene blue tests at 37.5°C., although a useful guide to keeping quality with aged samples, were of small value with freshly pasteurized milk.

Raw milk aged at 40-50°F. showed an increase in peptonizing organisms, and the keeping quality of the milk, when pasteurized, was reduced. Colony counts on plates gave no indication of the keeping quality of pasteurized milk, but they gave a general idea of the standard of production and handling of the raw milk.

The Bacteriological Control of Drinking Water

Memorandum No. 3 of the Public Health Laboratory Service, *Monthly Bull. Min. of Health* and the *Public Health Laboratory Service*, Jan., 1951, **10,** 18-22.

This memorandum is a synopsis and simplification of the *Ministry of Health Report No.* 71 (1939) and should be read by all those interested in water examination and the interpretation of results.

Tracing a Typhoid Carrier by Sewage Examination

In the same Bulletin an account is given of an ingenious device for detecting in high dilution small numbers of an organism it was desired to locate. Gauze swabs were suspended in a drain and left in position for some days. The swabs were then immersed in a jar of enrichment medium which was then incubated. The usual plating procedure was then followed. This technique has obvious possibilities for bacteriologists other than medical.

A.T.R.M.

POULTRY HUSBANDRY

Hatchability and Egg Production

Further confirmation of the presence of some valuable nutrient in old deep litter is given in a paper by Kennard entitled " Floor Litter Management as a Factor in Poultry Nutrition " published in the *World's Poultry Science Journal*, 1950, **6,** 177-82. Kennard reports on the improved hatchability, growth and lowered mortality achieved when feeding birds on old, as opposed to new, floor litter. The effect of differing riboflavin levels is also discussed. In the same Journal (*ibid* 183-7) Kennard and Chamberlin discuss the " Mortality of Chicks as affected by the Floor Litter." The authors demonstrate the reduced mortality from coccidiosis experienced when litter is retained over a period.

Comstock, Glazener, Dearstyne and Bostain have some interesting comments on " Egg Production and Hatchability in the First and Second Years in Turkeys " in *Poult. Sci.*, 1950, **29,** 508-12. These writers consider that even carefully selected birds retained for a second year will not increase flock average production. They point out, however, that hatchability does not show the same decline as does egg production intensity in the second year compared with the first. It is suggested that selection for hatchability should lead to fairly rapid improvement for that character.

A series of interesting papers by Wiley in *Poult. Sci.*, 1950, **29,** 570-4, 595-604, and 605-10 deals with " The Influence of Egg Weight on the Pre-Hatching and Post-Hatching Growth Rate in the Fowl." Wiley concludes from the evidence brought forward that chick size is limited

by the space in the egg shell, and that eggs of heavier weight give heavier chicks. This advantage appears to be lost by the twelfth week. No constant difference was observed in rate of feathering, mortality or hatchability for either weight group. The weight advantage at hatching suggests that the heavier eggs would appeal to the table poultryman. This attraction gains confirmation by Wiley's data showing that the shank length-body weight ratio was greater in small egg birds. This larger ratio indicates a less desirable body conformation.

Egg Production

Increasing costs have made the need to improve output per bird in this country a matter of paramount importance. It is, therefore, of some interest to examine the figures for egg production of a number of countries now published in *Poultry and Eggs*, a commodity report of the F.A.O. (September, 1950). In Europe the highest producers are Holland and Denmark, with figures of 170 and 152 respectively. In both countries it is emphasized that, as exporters of eggs, the need to increase production indices has been urgent; both pay tribute to the influence of their stock improvement schemes.

The U.S.D.A. *Technical Bulletin No.* 1018 (August, 1950) on " Competitive Position of Chickens and Eggs in the United States," by R. P. Christensen and R. L. Mitchell, gives a more extensive survey of conditions in the U.S.A. and refers to the cause for the increase in the production index of the birds in that country, which has nearly approached that of the two countries already cited. It is pointed out by the American authors that there has been a 35 per cent increase in the rate of lay between 1925-29 and 1945-49. This increase is attributed to the effect of their stock improvement schemes, an increase in the proportion of pullets in their laying flocks, and improved feeding. Of interest to poultry keepers in this country will be the statement that rate of lay has been highest on farms with large flocks where a high degree of specialization is possible. There is the further comment that the costs of producing eggs declined by about 10 per cent relative to other livestock products by virtue of the increased quantities produced.

Egg Quality

Cleaning eggs has recently received a good deal of attention, and in *Poultry Science*, 1950, **29,** 833-6, W. F. Rhodes and G. F. Godfrey in a paper entitled " The Effect of Washing Eggs on the Cuticle as Measured by Moisture Loss and Hatchability " hold the following views. Their experimental work included the washing of eggs in hot water, detergent solutions and a hot solution of lye; none of these methods removed sufficient cuticle to effect a significant reduction in loss after 14 days of incubation or to affect hatchability. In the same Journal (*ibid.* 1950, **29,** 888-94) J. A. Pino in an article on the " Effect of Washing with a Hot Detergent Solution on Keeping Quality and Hatchability of Eggs " reached similar conclusions so far as hatchability was concerned. The author also maintains from the results of his experiment that internal quality was not adversely affected, and the eggs showed no differences

from unwashed eggs when stored under similar conditions. Pino doubts whether the cuticle is any protection against bacterial invasion, but argues that if harmful bacteria exist on the surface of the shell the action of washing may widen their possible field of operations. For this reason he urges washing with a bactericidal solution.

Nutrition

As may be expected, the animal protein factor continues to be the subject of a number of papers. Further evidence on the value of old floor litter as a source of B_{12} is forthcoming in a contribution by E. R. Halbrook, A. R. Winter and T. S. Sutton on " The Effect of Management on the Vitamin B_{12} Content of Poultry House Litter " published in *Poultry Science*, 1950, **29,** 672-8. The authors endorse earlier findings that chicks grow well on unchanged deep litter which is at least a year old, and compare favourably with control chicks having a B_{12} supplement. Most of the work on A.P.F. is related to young growing stock or hatchability of eggs ; a paper by J. L. Skinner and J. H. Quisenberry on " Some Effects of High Efficiency and B_{12} in Chicken Breeder Rations " in the *Proceedings of the Poultry Science Association*, 1950, 39*th Meeting*, is, therefore, particularly interesting because these writers refer to the improved egg production resulting from addition of A.P.F. This seems to be the first account demonstrating that an A.P.F. supplement improves egg production and that the improvement consequent upon the feeding of animal protein is not due solely to a better amino-acid balance.

Allied to the interest in the A.P.F. is that concerned with the use of antibiotics (*N.A.A.S. Quarterly Review*, *No.* 11). Increasing evidence is now forthcoming to suggest that antibiotics stimulate growth by changing the intestinal microflora from an undesirable type to a desirable type. A. C. Groschke in a paper on the " Relation of Growth Stimulating Properties of Antibiotics to Unidentified Growth Factors Required by the Chick " in the *Proceedings of the Poultry Association*, 1950, **39,** argues that the so-called " whey factor " may be one of the factors synthesized by the desirable microflora. It will be remembered that the whey factor is the name which has been given to an unidentified part of the A.P.F. complex. The work of Groschke and others suggest that the unidentified factors in the A.P.F. complex may be of greater importance compared with B_{12} than has hitherto been thought.

R.C.

CROPS AND PLANT BREEDING

Economics of Plant Breeding

There are few countries in the world where work on plant breeding forms such a high proportion of the total effort devoted to research and technical development as in Sweden. An estimate of the economic return from plant breeding given by Müntzing (*Züchter*, 1950, **20,** 1-8) is, therefore, of interest. He shows the increases in yields per acre by comparing the periods 1886-90 and 1944-48 ; forms an estimate of the fraction of these increases attributed to plant breeding ; and then calculates the monetary return on a national basis. He considers that over all crops the improvements due to plant breeding represent an annual return of about Kr. 100,000,000 (£7,000,000). This figure, of course, dwarfs the expenditure on plant breeding.

Müntzing also reviews the methods of plant breeding used in Sweden, including the investigation of induced mutation and induced polyploidy.

Polyploid Rye

In another paper (*Hereditas, Lund*, 1951, **37,** 17-84), Müntzing reviews the cytogenetic properties and practical value of tetraploid rye. The best of his tetraploid strains ($2n=4x=28$) is one based on the variety Steel. This tetraploid is not inferior to the diploid variety in yield, earliness or winter-hardiness. Its grains are half as big again as diploid grains, and it has distinctly better baking quality. In spite of the larger seeds, it does not seem to be necessary to increase the sowing rate, as the better establishment of the tetraploid compensates for its larger seed size.

If small plots of tetraploid rye are exposed to pollen from diploid strains, a substantial reduction in yield results, for triploid grains usually abort. This will probably not cause much trouble on a farm scale, for in a large plot the abundance of their own pollen protects the tetraploids. In comparing yields of tetraploid and diploid, the depressing effect of the diploid on the tetraploid was circumvented by comparing each with a wheat variety in separate, parallel trials.

A disadvantage of tetraploid Steel rye is its straw-length, 15 *per cent* greater than the diploid. While this does not lead to more lodging, it can cause difficulty at harvest. A tetraploid based on the short-strawed variety King II shows promise of avoiding this difficulty. Other improvements in tetraploid rye are expected to be obtained by basing the tetraploid strains on a greater number of plants and also by using inter-varietal crosses.

Mutations

Ever since Muller (with *Drosophila*) and Stadler (with cereals) discovered that mutation could be induced by irradiation with X-rays, there has been an enticing prospect of making practical use of the genetical variation thus produced. In fact, the results have been rather disappointing. Complete ignorance of the factors influencing the direction of mutation (sometimes expressed in the assertion that mutations

DEVELOPMENT OF THE HILL AND MARGINAL LAND OF CORNWALL (See pp. 178-84)

W.A.E.C. Reclamations—Cardinham, 1950

W.A.E.C. Reclamations—Ewe Hoggs on 4-year-old pasture, 1950

Hill Land Improvement Scheme—Additions and Repairs to Existing Buildings

DEVELOPMENT OF THE HILL AND MARGINAL LAND OF CORNWALL (See pp. 178-84)

Hill Land Improvement Scheme—Fencing of Cultivated Land from the Moorland

are random in direction) has been a handicap in this work. Attention has usually been concentrated on the homozygous forms produced by inbreeding. Two recent papers from Svalöf demonstrate very well the importance of examining the heterozygote more carefully.

Nybom (*Hereditas, Lund,* 1950, **36,** 321-8) used three *erectoides* mutants produced by Bonus barley after X-irradiation. Homozygous *erectoides* plants have shorter and stiffer straw and shorter, denser ears, thus resembling the *erectum* type of two-row barley. Nybom crossed each homozygous mutant with the other two and also crossed each with Bonus. In every case the culm length of the F_1 hybrid was greater than that of the taller parent, and in all cases but one the ear length was greater than that of the longer-eared parent.

Gustaffson, Nybom and von Wettstein (*Hereditas, Lund,* 1950, **36,** 383-92) used mutants defective in chlorophyll, which had been discovered by Nilsson-Ehle in Golden barley. Their results show that the heterozygotes were superior in yield to normal homozygotes under the " standard " conditions at Svalöf, 5 cm. spacing and 200 kg. potassium nitrate per hectare. If the spacing was increased to 10 cm. without altering the manuring, the normal homozygote yielded more than the heterozygotes, while at 10 cm. with 500 kg. manure, the heterozygotes were again superior.

J.L.F.

CROP HUSBANDRY

Malting Barley

It is probable that brewers will pay more attention to quality in barley in the immediate future than in the past ten years. The rapid increase in the number of combine harvesters, together with inadequate drying facilities in some districts, has produced some inferior samples. This means that those growers who pay attention to producing what, pre-war, would be looked upon as good quality malting grain are likely to benefit considerably.

A. Cory-Wright in an article " The Malting Process " (*World Crops,* 1950, **2,** 451) points out that various character malts are needed for various purposes and that all barley which will grow readily is maltable. He further indicates that the most difficult barley to grow or purchase is that suitable for the brewing of pale ale, which therefore commands the highest price. For this, Plumage Archer and Spratt Archer are suitable varieties, but Pioneer has not yet received the unqualified approval of the brewers. Varieties such as Kenia, Maja, Freja and Ymer are not popular with brewers of pale ale. These varieties have their uses for other types of beer, e.g., lager. It is stated that each bulk of grain is treated on its merits rather than by rule of thumb methods.

D.H.R.

VEGETABLE CROPS

Large Seeds as a Breeding Objective for Quick Maturing Vegetables. SCHWANITZ, F. *Züchter*, 1950, **20,** 37-8.

In 1941 experiments in Germany showed that heavier yields of cress and radishes were obtained from large seeds than from small ones. The quantity of endosperm in the seed is more likely to affect the yield of quick-maturing plants than that of long-term plants.

Effects of Size of Planting Material on Yield of Shallots. WARNE, L. G. G. *J. R. hort. Soc.*, 1949, **74,** 407-9.

When large bulbs are planted, the maximum yield of small daughter bulbs is obtained. When small bulbs are planted, the total weight harvested is less, but if the crop is graded, the aggregate weight of large daughter bulbs is found to be greater than when large bulbs are planted.

The incidence of bolting is greater when small bulbs are planted.

Stump Saved Cabbage Seed Helps to Avoid Bolters. DAWSON, C. D. R. *The Grower*, 1950, **33,** 1158-9.

A period of low temperature is probably one of the chief causes of initiation of bolting in cabbages. Nevertheless, the plants must reach a certain size or physiological age, before a cold spell can bring about this effect.

Late-sown crops tend to bolt much less than early-sown, presumably because the critical age has not been reached before the last of the cold spells.

In the case of spring cabbage, the author recommends the use of stump-saved seed of strains which have been selected against bolting for several generations. Stump seed is produced by sowing in July or August and thoroughly roguing for bolters as the crop matures. The heads are cut and the stumps allowed to make side shoots which flower fifteen months later. The crop thus runs to three years, but more efficient roguing can be carried out than is possible with the more usual two-year method in which the seed is sown in spring.

E.J.W.

Lime-induced Chlorosis ; Relation between Active Iron and Citric and Oxalic Acids. McGeorge, W. T. *Soil Sci.*, 1949, **68**, 381-90.

In Arizona both top fruit and annual crops are subject to lime-induced chlorosis attributed to iron deficiency. Corrective measures tried successfully involve either the use of sulphur applied to the root systems or injection of iron into the plant. The experiments devised were an attempt to find out whether active iron could be correlated with the presence of citric and oxalic acids in the plant. In annual crops less active iron was found in chlorotic leaves whilst the citric acid content had increased. It was discovered, also, that the oxalic acid content decreased in chlorotic leaves. When using monocotyledons, the findings were somewhat different and there is no relationship between active iron and citric acid postulated. In pot experiments with lupins, when sulphur was applied to the root system, active iron and oxalic acid increased, whilst citric acid content fell. Apparently, injections of iron citrate produced the same chemical effect on apples and peach leaves as the application of sulphur to the soil in which the lupins were grown. In a more practical vein, the reason why white and blue lupins fail on calcareous soils can be associated with low active iron and high citric acid content in the plant tissues.

Annual Report of Department of Hop Research, 1949, Wye College

As a perennial crop the hop is generally subject to a long term and generous manuring programme and the hop-garden is not likely to suffer from the more common deficiencies of the major elements which beset the grower of annual crops. Nevertheless, in spite of heavy dressings of organic or inorganic fertilizers, hop gardens are not free from nutritional anomalies, and the three following abstracts reporting development in hop research in this country indicate the nature of problems which can arise.

Hop Manuring and Cultivation Experiments. Burgess, A. H.

A detailed account is given of trials with hops over a period extending from 1930 to 1948, involving both manuring and cultivation practices. In the experiments concerned with manuring, yields during the first seven years showed no significant difference using either organic or inorganic manures separately or together. The ultimate effect of sulphate of ammonia was to render the soil acid and to cause a deterioration in soil structure. As a consequence of this, yields fell so that over a period of time organic fertilizers are preferable. Sulphate of ammonia, when applied during four intervals throughout the growing season, gave no better results than one initial application. The optimal annual dressing for nitrogen in Kent lies in the region of 270 lb. per acre.

Combined experiments were carried out at the same time to ascertain the effect of deep and continual cultivations as opposed to one surface treatment in the spring. There were no significant differences in yield from either way of cultivating the garden.

Experiments on Magnesium Deficiency in the Hop Plant. Thompson, F. C., Cripps, E. G. and Burgess, A. H.

Symptoms of magnesium deficiency are described for the hop plant growing in an old established garden situated on a brickearth soil. Affected hills were either scattered about as individuals or occurred, 10 to 30 together, in patches. The leaves on the main bine showed marked interveinal chlorosis, and defoliation of the lower leaves was severe. Laterals were short, stiff and retarded. Leaves were sampled from healthy and unhealthy plants and the magnesium content fell from 0.89 to 0.58 per cent in the chlorotic leaves. There was also an inverse relationship between this element and potassium, involving an increase in the latter as magnesium fell. Soil analyses showed that the available potassium and phosphorus in soil samples from underneath affected plants was high. As a result of applying 10 cwt. sulphate and withholding muriate of potash, the symptoms almost disappeared and yields increased from 6 to 15 cwt. per acre.

As the available magnesium in the soil extracted by Morgans reagent was adequate for growth purposes, it is assumed that this form of magnesium deficiency in hops is induced by an excess of potassium in the soil. Further experimental work has demonstrated that it is possible to induce the deficiency by applying heavy dressings of potash fertilizers to hop gardens where growth was previously healthy.

The authors stress that this form of magnesium deficiency occurring on neutral or alkaline soils is quite different from the one occurring where the deficiency appears on acid soils. Under these conditions the symptoms are complicated by other factors which result from the acid soil complex.

The Effect of Soil Acidity on Growth of Hops. Thompson, F. C., Cripps, E. G. and Burgess, A. H.

Hops growing in an acid soil (*p*H 4.6) derived from Tunbridge Wells sand on the Weald of Kent showed a range of symptoms considered to be due mostly to manganese toxicity. The plants in question were stunted, leaves were chlorotic and showed necrotic spotting interveinally. As the necrosis progressed, the leaf wrinkled and appeared deformed. An analysis of leaves collected from affected plants in June showed that chlorotic leaves contained 2,000 p.p.m. manganese in the dry matter.

On young replants, symptoms of iron deficiency were diagnosed in the youngest leaves. This induced iron deficiency was attributed to the unusually high content of manganese. As the season progressed, these plants recovered from iron deficiency but the lower leaves showed a combination of symptoms due to magnesium deficiency and manganese toxicity. The magnesium content of the leaf and soil were low.

The complexity of the symptoms recorded in this interesting hop garden demonstrates the difficulty of accurate diagnosis. Chemical analysis of healthy and unhealthy leaves, however, showed that toxicosis of one element was the key to the underlying trouble.

W.P.

FRUIT

Maleic hydrazide—a New Growth Inhibitor

Maleic hydrazide, or more properly, 1,2-dihydropyridazine 3,6-dione, has been found by D. L. Schoene and Otto L. Hoffmann (*Science*, 1949, **109,** 588-90) to have a pronounced but temporary inhibiting effect on plant growth. The amount and duration of inhibition appears to be directly proportional to the concentration used and the inhibition is obtained with little visible damage to the plants.

The compound itself can be dissolved in water up to 2,000 p.p.m. (0.2 per cent) and more concentrated solutions can be prepared using the triethanolamine salt. Insoluble salts can be prepared with heavy metals and both these and the soluble salts function as growth regulants.

The growth of tomato plants was inhibited for two months by spraying with 2,000 p.p.m. of maleic hydrazide, its cupric salt or its zinc salt. Root growth was also inhibited. Otherwise the plants appeared normal apart from some chlorosis which developed after one month on the younger leaves. Growth was eventually resumed and the plants blossomed. Plants survived treatment at 1 per cent, showing no necrotic spots. Swards containing " bluegrass, bentgrass, crabgrass, plantain and chickweed " were also checked to varying degrees by treatment with 8, 4, 2 and 1 lb. per acre of maleic hydrazide applied in 200 gallons of water ; normal growth was resumed after the quiescent period. This experiment was carried out in a dry period and similar results might not be obtained under more rainy conditions. Tomato plants were checked also by soil applications, though rather more chemical was required.

Experiments with maleic hydrazide to delay blossoming of fruit trees, as a means of escaping frost injury, have been begun by D. G. White and William C. Kennard (*Proc. Amer. Soc. hort. Sci.*, 1950, **55,** 147-51). Previously, experiments by various workers using growth substances such as naphthalene-acetic acid applied to fruit plants either just before blossoming or in the preceding summer had produced conflicting results. In some cases retardation of blossoming up to fourteen days resulted, whereas in others no effect at all was observed or even considerable injury. The work suggested, however, that a suitable growth regulant might produce the desired retardation.

Maleic hydrazide was selected for trial on account of its unique properties. Unfortunately samples were not obtained until peaches, cherries and currants were already in flower, but certain other fruits were treated before blossoming with dilutions of 1,000, 1,500, 2,000 and 3,000 p.p.m. of the diethanolamine salt in water. The treatment was made on April 27 by means of a hand sprayer.

Golden Delicious apples were sprayed at early pink bud stage. They were not retarded but almost all the fruit on the treated limbs fell off at an early stage of development.

Premier strawberries were sprayed when there were many flower buds but none had opened ; within a week flowers had opened on all plants. Three weeks later the control plants were still flowering but

the treated ones had ceased to flower. The fruits on treated and control plants developed at the same rate and there was no sign of injury, although the vegetative development of the treated plants was retarded. A week later the plants sprayed with 1,000 p.p.m. began to flower again; unfortunately no further observations could be made as the plants were then ploughed under. Blossoming had, however, apparently been temporarily checked by the treatment.

Bristol black raspberries showed no signs of flowering when they were sprayed on April 27; the leaflets were expanded only about 1 cm. and side branches were just beginning to appear. Four weeks later the control plants were in full bloom; the plants treated with 1,000, 1,500 and 2,000 p.p.m. showed no injury and did not come into blossom until 24 days later. Treatment with 3,000 p.p.m. delayed blossoming 38 days and apparently caused some injury. With all treatments the ripening of the berries was less retarded than the blossoming and full crops were produced. The growth of new canes was a little delayed but otherwise normal. The authors believe that a delay in blossoming of about ten days could be achieved with lower concentrations of the chemical.

Maleic hydrazide is considered by A. W. Naylor and E. A. Davis (*Bot. gaz.*, 1950, **112,** 112-26) to differ from the familiar growth regulating substances in that it does not promote growth at any concentration. In their experiments it failed to induce the initiation of root primordia or fasciation or true epinasty in any of the range of monocotyledonous or dicotyledonous plants tested. In every case the first effect on vegetative growth was a cessation of elongation of the internodes and an increase in stem diameter. In plants treated with low concentrations the meristems eventually became active again and produced normal leaves. Effects on flowering ranged from almost complete suppression in sunflower and peanut, and sterilization of the staminate inflorescences in maize, to retardation and phyllody in *Xanthium*. Flowering of tobacco was suppressed by application through the soil. The authors suggest that maleic hydrazide should be considered as a growth inhibitor for the present at least and that besides its practical uses it may be valuable in the study of plant physiology.

Experiments with maleic hydrazide on fruit plants are just beginning in this country and it will be interesting to observe its effects under our conditions.

H.B.S.M.

GLASSHOUSE CROPS

Cucumbers. Experimental and Research Station, Cheshunt. Annual Reports, 1947, 1948 and 1949

The experiments in 1947 were designed to compare the relative values of composted straw and horse manure in the preparation of cucumber beds, and also to determine the effect of replacing the standard fertilizers used for this crop by liquid feeding. In eight plots the beds were prepared by mixing two parts of sterilized loam with one part of strawy horse-manure. Three of these were fed with a proprietary soluble fertilizer mixture, the remainder being top-dressed with the standard mixture in the dry state. This consisted of a proprietary blood, fish and bone mixture of comparable analysis to the liquid feed. This was applied at the rate of 2 oz. per yard run of bed at intervals of approximately 14 days and commencing about 14 days after the first top-dressing with stable manure.

This stable manure dressing is usually applied a week or two after the first fruits are cut, and it may be preceded by one or two dressings consisting of equal parts superphosphate and dried blood, depending on the condition of the plants. In 1947 the seed was sown on March 7, the plants were put out into the borders on April 10, first fruit was cut on May 5, the first top-dressing (stable manure) was applied on May 21, and the last " feed " (i.e., fertilizer mixture) applied on August 14. The last fruit was picked on October 29.

In the plots receiving liquid feed, the solution contained 7 per cent nitrogen, 6 per cent P_2O_5, and 5 per cent K_2O. Six other beds were prepared by mixing two parts sterilized loam with one part of straw treated with a compost hastener. Half of the six beds were fed with the soluble fertilizer, and half in the usual way. The average yield from the plots made up with horse manure and receiving dry fertilizers was at the rate of 76 tons per acre, but where soluble fertilizers were applied the crop was 77.03 tons. The yield from the composted straw plots with dry fertilizers was 72.72 tons but where soluble fertilizers were used the crop was 78 tons.

In 1948 an experiment was laid down to compare the effects of applying fertilizers in both solid and liquid form, and no fertilizers at all. The yield from the plots where fertilizer was applied mechanically in liquid form was 60.25 tons per acre, and the yield from plots receiving solid fertilizer applied by hand in the usual way was 57.23 tons. The difference in yield is not regarded as significant, but in 1948 the cucumber crop at Cheshunt was light, partly due to a sudden development of Root Knot eelworm. All top-dressing fertilizers were withheld from two other plots, and the yield fell to 42.18 tons per acre, clearly indicating the need for top-dressing the cucumber crop.

Cultural operations for the cucumber crop in that year were as follows : sown February 27, planted into borders March 25. First top-dressing (stable manure) May 1, first fruit cut April 22, last " feed " applied July 24, last fruit cut September 16.

In two plots magnesium sulphate was incorporated while making up the beds at the rate of $\frac{1}{2}$ lb. per yard run. There was no apparent

effect on the foliage, but the yield of 66.08 tons per acre was slightly higher than from the controls.

A problem which has confronted cucumber growers for many years is sickness of border soils in old houses. However much care and attention is devoted to the collection and preparation of materials for the cucumber beds, sooner or later the roots enter the base or border soil, and it is here that trouble invariably starts. Steam sterilization of the borders, or even the whole of the surface soil in the houses seems to be only a palliative, and for some years experiments have been conducted at Cheshunt in an effort to overcome this trouble. In 1949, experiments included the provision of a core of either gravel or washed clinkers to serve as drainage inside the bed itself. In section the core was approximately triangular, and occupied about half the original mass of bed, which was about 18 inches wide and 16 inches deep. The remainder of the bed was composed of a mixture of two parts loam and one part strawy horse manure. Both of these treatments resulted in crops of 72 tons per acre, whereas the next best yield was 65 tons per acre from control beds made up entirely with two parts loam and one part manure. In other experiments, standard beds were compared with beds made up with composted straw, and composted straw plus stable manure in two different proportions, using the same proportions of loam as in the control beds. There was little difference in the weight of crop from the different treatments, but an attack by Root Knot eelworm in one portion of the greenhouse concerned upset the results of this experiment. The work, however, confirms previous results which suggested that composted straw was as suitable as horse manure for the cucumber crop.

E.S.

HERBAGE

Advisory Methods for Grassland Improvement

A bulletin on this subject (*Farm Advisory methods for Grassland Improvement*. Organisation for European Economic Co-operation, Paris, 1950.) gives a brief symposium of methods adopted by participating countries. In France, Belgium and Holland this work is undertaken by bodies entirely State organized and financed as in Britain, while in the Scandinavian countries and Switzerland voluntary associations of farmers, co-operatives and merchants undertake grassland advisory work which is financed partly by individual subscription and partly by State aid. It appears that the financial burden is being increasingly assumed, however, in these latter countries by the State. Advisory methods employed by the various countries are generally familiar in Britain, and include farm visits, lectures, films, brochures and broadcasts. In Holland particular emphasis is made on the establishment of so-called model farms. Probably a better term would be " example farms." This procedure is considered necessary because of the need for fitting into the farm organization improved techniques of grassland

utilization and conservation simultaneously with greater grassland production. While demonstration plots are adequate to convey methods of improved production, it is necessary to display on the farm the complete integration of such practices. The model farms are suitable private farms and results are demonstrated through appropriate systems of financial and technical book-keeping.

The system is based on the assumption that the research worker will be assisted by the advisory officer who will arrange the practical application of the results of research and find a farmer prepared to put them into practice.

T.E.W.

MYCOLOGY

Mushroom Diseases and Competitors

Atkins [1] and Glasscock [2] have each given accounts of the principal diseases and competitors of cultivated mushrooms in this country. Diagnostic descriptions and diagrams of the causal organisms are included by Atkins.

Diseases

White Mould or Bubble (*Mycogone perniciosa*). This fungus appears as a white mould over the surface of the mushrooms. Affected caps in a few days break down to a malodorous, shapeless mass, often exuding characteristic brown droplets. Often clumps of mushrooms are malformed. High temperatures favour the disease so that if it is present, the temperature of the house should be dropped to at least 55°F. Spraying the beds between flushes with 2:2:100 Bordeaux mixture may reduce the rate of spread of the disease.

Verticillium Disease (*Verticillium malthousei* and *V. psalliotae*). The characteristic symptom of this disease is irregular, light brown spotting on the caps of the mushrooms, sometimes accompanied by a scanty, white mould growth. Infected buttons become dry and the stems tend to split. High humidity and high temperature encourage the disease so that if it occurs, the temperature should be lowered and the ventilation increased. Insects may spread this disease and should be controlled. All infected buttons should be immediately removed and burnt.

Cobweb Disease (*Dactylium dendroides*). Infected mushrooms are covered with a fluffy mass of white mould which becomes rather pink. The affected mushrooms turn brown and rot away completely. The part of the bed concerned and a margin of at least six inches round it should be sprayed with 5 per cent formalin before watering. The temperature should also be reduced and the ventilation increased.

Bacterial Spot or Brown Blotch (*Pseudomonas tolaasi*). The symptoms of this disease are small, superficial yellow spots on the caps. The spots later turn brown. Globules of water present on the caps favour the development of the disease, so ventilation should be sufficient after watering to dry the surface of the mushrooms.

Bacterial Pit. On affected caps there are small pits or depressions which often contain masses of bacteria. Some writers have attributed the damage to these bacteria but others believe the pits to be associated with mites. Atkins notes that the pits are often found below the surface of the caps and the covering wall collapses into them.

Mummy Disease. The cause of this infectious condition is unknown though it has been suggested that it may be due to a virus. Affected mushrooms have small, tilted caps on long slender stalks. Growth may cease in the button stage and the mushrooms become grey, dry and spongy. The disease spreads through the beds at the rate of about one foot in 24 hours. The progress of the disease may be checked by making narrow trenches across the beds 6-8 feet beyond the visibly affected mushrooms.

Competitors

Truffle (*Pseudobalsamia microspora*). The mushroom bed compost and often the casing soil may be overrun by the thick cream mycelium of this fungus. Many fruiting bodies are then formed. These are irregularly lobed structures up to 1 inch diameter, at first cream but later becoming reddish brown. They liberate spores which are extremely resistant to both heat and fungicides. Because the spores are so difficult to kill, no satisfactory control measures exist. In houses where the disease has become a problem the beds should be spawned at or below 60°F. so that the truffle spores have little chance to germinate before the mushroom mycelium is established.

Damping Off (*Fusarium* sp.). Through the presence of *Fusarium* sp. normal cropping is not obtained. There may be little or no production or after a good first flush small, withered buttons only are formed. A third symptom is that a proportion of the inside of the stalks are dry and pithy and usually coloured brown. Once the disease is established there is no effective control. Atkins suggests that the spread of the disease may be limited by cutting channels through the beds down to the bed boards and spraying them with 2 per cent formalin. Where the disease has been troublesome Glasscock [2] advises that the woodwork in the houses should be treated with creosote.

White Plaster Mould (*Scopulariopsis fimicola*). This fungus resembles patches of plaster or lime in the beds. Later the patches may become faintly pink. This competitor is favoured by alkaline conditions and is usually prevented by addition of gypsum to the compost.

Brown Plaster Mould (*Papulaspora byssina*). This fungus also appears as white patches but in a few days turns brown with the formation of a mass of powdery granules called bulbils. It is probably introduced into the house with the compost and may usually be avoided by hygienic composting conditions.

With the exception of the plaster moulds, bacterial spots and mummy disease, most of the harmful fungi are probably introduced into mushroom houses with the composting soil. Both authors stress the importance of partial sterilization of the casing soil. In Bulletin 34 [2] methods of treating the soil by steam, electricity and formaldehyde solution are described. House hygiene, with particular reference to the removal of old beds and disinfecting the empty houses, is also discussed. Spraying down with a power sprayer with a pressure of at least 70 lb. per square inch is recommended, using a 5 per cent formalin solution. Alternative spray materials are 1 per cent copper sulphate and 1 in 15 lime sulphur.

References

1. Major Diseases and Competitors of the Cultivated White Mushroom. 1949. Atkins, F. C. *Mushroom Growers' Association.*

2. *Ministry of Agriculture and Fisheries. Bulletin No.* 34. Mushroom Growing. (Revised 1950. Glasscock, H. H.)

H.E.C.

ENTOMOLOGY

Stem Eelworm and Clover. Goodey, T. *Ann. appl. Biol.*, 1950, **37,** 324-7.

This paper gives a complete account of the clover eelworm problem. It deals with the history of this form of clover sickness and lists the degrees of susceptibility and resistance of the various clovers and legumes to eelworm attacks. Symptoms are described and the dispersal of the eelworm as a seed-borne organism is discussed, together with the treatment of seed. Mention is made of two Swedish varieties of red clover, obtained by mass selection, which are now in commerce and have proved capable of giving good yields on infective soils in Sweden and Denmark ; the names of these varieties are Merkur and Resistenta. Our state of knowledge as to alternative weed hosts of the clover strain of eelworm is discussed.

Observations and Experiments On Stem Eelworm (*Ditylenchus dipsaci, Filipjev*) **1936, with Special Reference to Weed Hosts.** Southey, J., and Staniland, L. N.

The occurrence of stem eelworm has been recorded in connection with a variety of weeds associated with such crops as red clover, oats, mangolds, strawberry, teazle, phlox and narcissus. In some cases host transference experiments have been made ; for example *D. dipsaci.* has been successfully transferred from oats to strawberry, and from strawberry to onions. It is considered that the strawberry race is identical with the common oat race.

The Strawberry Aphid, *Pentatrichopus fragifolli (Cock)* and its Control. Dicker, G. H. L. *Ann. Rept. East Malling Res. Sta.*, 1949, 132-8.

The life history of this important vector of strawberry virus diseases is reviewed and experiments in its control are described.

A complete kill of aphids on infested plants was obtained when they were dipped in solutions containing 0.0006 per cent of parathion, with extra spreader.

In field trials the maximum control was obtained by the use of parathion at a strength of 0.005 per cent with the addition of extra spreader ; the spray was applied at 250 lb. pressure using 400-600 gallons per acre.

Experiments were also carried out with the systemic insecticide, bis (bis-dimethylamino) -phosphonous anhydride. The leaves of potted strawberries were dipped and young leaves and runners produced subsequently were found to be toxic to aphids. The anhydride at a strength of 0.094 per cent at 100-150 gallons per acre at the end of June greatly reduced the infestation throughout the summer and gave better results than parathion. No insecticidal activity was, however, obtained when growth was not active. It is stressed in this paper that parathion should be used as a *pre-blossom* spray and that the systemic insecticide should, for the time being, be used only on runner beds and applied in late May and June.

The Broad Mite. Wilson, G. Fox. *J. R. hort. Soc.*, 1950, **75,** 69-74.

The broad mite *Hemitarsonemus latus*, Banks, is a little-known pest of various glasshouse plants. Well-known plants included in the list of those attacked are chrysanthemum, cyclamen, dahlia and tomato.

Typical symptoms on several kinds of plant are illustrated ; these symptoms consist of a shiny brittleness of the leaves, accompanied by a puckering and downward marginal roll of the foliage. Bud-drop may also occur. Flowers of chrysanthemum may become malformed, rather similar to that produced by attacks of the tarnished plant bug.

A description of this microscopic mite is given and its life history described. Various control measures are discussed, but it has been found at Wisley that excellent results have been obtained by applications of finely ground flowers of sulphur ; mites are readily killed within an hour when the temperature of the glasshouse is 65° F. or higher.

L.N.S.

VIROLOGY

Stand unserer Kenntnisse ueber die Kraüselmosaikkrankheit (Viruskrankheit) der Kohlruebe. PAPE, H. *Nachr Bl.dtsch. PflSchDienst(Braunschw.)*, 9, 123-5.

This is an account of a mosaic disease affecting swedes in Germany. The virus appears to overwinter in swedes taken from diseased stands and stored in clamps for spring planting. Even plants with no external symptoms may harbour the virus and develop diseased foliage the following year. No evidence of seed-borne infection has been obtained.

Een virusziekte in Stoppelknollen. SAALTINK, G. J. *Tijdschr. PlZiekt.*, 1950, **56,** 95-8 (English summary).

A virus disease new to Holland was observed affecting turnips in a field at Wageningen. The leaves are crinkled, misshapen and often coarsely mottled. Later the older leaves fall off, leaving the crumpled heart leaves in the form of a rosette. The foliage generally is of a darker shade than the healthy plants and there may be a necrosis of the petioles and veins. The disease seems similar to that described as affecting swedes in Germany.

(There is no evidence as to which of the viruses affecting cruciferous plants is concerned in this and the preceding extract. In the reviewer's opinion, it is probably cauliflower mosaic virus which appears able to exist in several strains.)

Curly Dwarf, a Virus Disease of Globe Artichoke. LEACH, L. D., and OSWALD, J. W. *Phytopath.* (*Abstr.*), 1950, **40,** 967.

An extremely destructive disease of globe artichokes (*Cynara scolymus*), characterized by curling and dwarfing was observed in Monterey and San Mateo Counties, California, in 1946 and 1947. Affected plants at first produce abnormal buds, then become unproductive, decline in vigour, and often die. Preliminary investigations have shown this to be a virus disease transmissible to seedlings of artichokes and cardoon (*C. cardunculus*) by mechanical juice inoculations. After 25 to 30 days infected seedlings have symptoms consisting of extreme leaf distortion and internal necrosis of the petiole. Later, the seedlings show curling of the leaflets and complete dwarfing more suggestive of the disease in mature plants. All symptoms are masked by high temperatures. Thus far only artichoke, cardoon, zinnia and milk thistle (*Silybum marianum*) have been found susceptible to the virus. Field surveys show that the disease spreads rapidly in certain fields but very slowly in others.

Some Aspects Concerning Seed Transmission of Lettuce Mosaic Virus. GROGAN, R. G., and BARDIN, ROY. *Phytopath.* (*Abstr.*), 1950, **40,** 965.

Lettuce mosaic, which causes considerable damage in the commercial lettuce crops of the central coastal area of California, was seed-borne in all commercial seed lots which have been tested. In all lettuce seed fields so far examined, a high percentage of the plants were affected with

the disease. The amount of seed-borne mosaic carried by different varieties grown under comparable conditions varies from 1 per cent to 8 per cent, certain varieties carrying consistently higher percentages than others. In order to obtain accurate readings of seed-borne mosaic, seedlings must be given adequate room to minimize competition for space and light, otherwise readings will be low because of crowding out of weak plants or failure of symptom expression.

Attempts to rid seed of mosaic virus by hot-water treatment have failed because of the great reduction in germination before any apparent inactivation of the virus was affected. Separation of seed into light and heavy fractions by aspiration and gravity failed to increase or decrease the percentage of mosaic in any of the fractions.

Some Host Plants of Chrysanthemum Stunt Virus. Brierley, P. *Phytopath.* (*Abstr.*), 1950, **40,** 869.

Producers of florists' chrysanthemums (*Chrysanthemum hortorum*) have been remarkably successful in reselecting healthy stock since stunt was recognized as a virus disease. Nevertheless, practical control and other studies have been hampered by the lack of a quick test for presence of the virus. Test varieties of chrysanthemum selected by Olson and by Keller react after two to three months. Manual inoculation of 30 compositae, including eight species of chrysanthemum and species from 21 other genera, has thus far revealed three additional plants that expressed symptoms and nine that developed no recognizable symptoms but from which the stunt virus was recovered.

The florist's cineraria (*Senecia cruentus*) developed primary spots 20 to 30 days after inoculation, followed by upright growth with paler leaves ruffled at the margins. Cineraria promises to be useful as a test plant for the Chrysanthemum stunt virus.

K.M.S.

SOILS

The Nitrogen Nutrition of Cereals in Mixed Cropping with Legumes. Ehrenberg, P., *et al. Z. Pfl-Ernähr, Düng*, 1949, **43,** 122-32.

The pot experiments with oats and field beans described in this report on two years' work, are an extension of earlier trials with rye grown with peas or lupins, and are intended to throw light on the practice of growing cereals with legumes in order that the corn may benefit from the nitrogen secreted by legume nodule bacteria.

Six or twelve oat plants were grown with four or eight beans, with or without nitrogen fertilizer, on nitrogen-deficient sandy soil which received a basal manuring of phosphate and potash.

Oats grown with beans did not exhibit nitrogen deficiency symptoms and were a darker green than oats grown without beans. The nitrogen effect was still greater when the number of beans sown was doubled,

though some degree of etiolation appeared, probably because of the shading effect of the bean companion crop. The use of nitrogenous fertilizer reduced the apparent benefit of beans to oats.

Yields of oat grain were reduced by growing beans with oats in the first year ; in the second year they were slightly increased. This appeared to be a residual effect arising possibly from failure to remove from the soil all roots, etc., derived from the first year's harvest, though the soil was, in fact, sieved before starting the next season's sowing.

The experiments indicated that there is some foundation for the practice of sowing cereals with legumes, and that in the light sandy soil under test, the beneficial effects are likely to be due mainly to an increase in the water-holding capacity of the soil as a result of mixed cropping.

Band Seeding Legume Stands. Haynes, J. L., and Thatcher, L. E. (*Ohio Agr. Exp. Sta.*) *Crops and Soils*, 1950, **2**, 15-7.

In the seedling stage, legumes tend to take up insufficient plant nutrients for maximum growth. The good response of lucerne seedlings to supplementary phosphate led to fertilizer placement trials to see whether practical advantage could be taken of this fact in improving the stand of a lucerne-timothy mixture sown with a cereal.

Preliminary tests showed that drilling this mixture with superphosphate was superior to broadcast seedings, but with mixed grades of fertilizer, a rather poor stand was obtained because of injury to germination. The tubes from the grass seed box on a combine grain drill were, therefore, extended by means of lengths of garden hose wired at the lower end to the back of the drill boots, so that the seed dropped in the furrows behind the discs directly over the cereal-P.K. fertilizer band which lay 2½ inches below. Legume seedlings treated in this way made excellent growth and gave a better performance than any combination of broadcasting seed or fertilizer. When legume seed was broadcast instead of drilled over the cereal-fertilizer bands, seedlings as little as ½ inch from the outer edges of the cereal-fertilizer band behaved as seedlings receiving no fertilizer. Thus, accurate placement of the seed is important to success of the band method.

The trials also indicated that seeding rates of legumes may be one-fourth to one-third less than those needed for good stands by present broadcasting methods.

A.J.L.L.
W.M.D.

Phosphate Fixation and Availability. Williams, E. G. *J. Sci., Food Agric.*, 1950, **1**, 244-8.

Many factors influence the relation of fixation to availability of phosphate in the field. Preliminary experiments have been carried out on some acid soils in Scotland to discover (1) the rate of fixation,

(2) the effect of time of application, and (3) the residual effects.

(1) It was shown that superphosphate is very rapidly fixed under field conditions.

(2) Pot and field experiments showed no significant decrease in the effectiveness of added phosphate during 3 months in moist, *bare, uncultivated* acid soils.

(3) In field experiments the addition of 6 cwt. per acre superphosphate to plots which had received 0, 10 and 25 cwt. per acre superphosphate when cropped to oats in the previous year gave large responses with roots on every plot.

It should be emphasized that the following conclusions are only tentative :

(1) Superphosphate applied at seed-time is probably largely fixed by the time the plant can use it, and the freshly fixed phosphate is much less soluble than superphosphate but is still highly available. This is probably because it is concentrated as minute pockets of phosphate-rich soil in the root zone and this is enhanced by fertilizer placement.

(2) In the course of a year the inherent availability is reduced by as much as 50 per cent.

(3) The low residual effects are probably partly due to reduction in positional availability by ploughing and cultivation. The residues can generally be utilized only at the cost of low yields.

The practical significance of these conclusions is that :

(1) Superphosphate can, without loss of effectiveness, be applied to ploughed land several months before sowing, if no further cultivations are carried out.

(2) Phosphatic fertilizers should be applied appropriately for individual crops in turn rather than for the whole rotation.

R.D.R.

MACHINERY

Milking Machine Hygiene

The hygiene of milking machines, and in fact of all utensils used in connection with milk, has always been a problem calling for the utmost care. It is, of course, very difficult where steam is not available. It is impossible to keep hot water anywhere near boiling point, whereas with steam it is easy, with proper design, to maintain a temperature of at least 210° F.

For farms not equipped with steam producers, American makers of milking machines have provided a stand with clips to hold clusters in the vertical position, so that by attaching a small reservoir to the milk line and raising it to the appropriate height, the teat cups may be kept between milkings full up to the lips with a disinfectant solution of lye.

The efficacy of this method of hygiene has been studied by Morris and Coleman (*Agriculture*, 1950, **57**, 319-21). They carried out their investigations on farms in Devon where no steam was available and

where, in the past, there had been considerable return of milk because of its poor keeping quality. The article shows that, provided proper precautions are taken, a 0.5 per cent solution of lye (caustic soda) can produce satisfactory results. The method does not call for a washing of the cluster before milking.

There is also a long article by Batt in the *N.Z. J. Agric.*, November, 1949, **79,** 487-92, dealing with the use of caustic soda in the hygiene of milking machines, but from rather a different angle. In the past, in that country great emphasis has been placed on the use of hot solutions of caustic soda to cleanse the rubber parts from fat. Rubber has a marked affinity with fat and if this absorption is permitted to mount up, the rubber surface becomes cracked and spongy. This causes rapid wear and difficulty in sterilizing. The article is well illustrated and also makes reference to the use of hydrochloric acid to remove " milk stone " from pipe lines.

From the angle of the trade, it is interesting to note the recent development of mobile milking machines. Among such machines now in production is one which has four units and incorporates a recorder.

The majority of the portable milkers are on wheeled trollies, with an electric motor to plug in at wall switches or a small I.C. engine. A more recent introduction is a machine, mounted on a gantry rail behind the cows, that can be easily moved along a shippon. Such outfits have for some time been in use in Scandinavia.

The cooling of milk on farms has always been a problem, and more and more attention is being paid to artificial methods. Recent trends are towards the use of chilled water in place of brine and direct expansion coolers. In these units the expansion coils of the cooler are situated in a water tank. Between milkings a low-powered compressor builds up a block of ice around the expansion coil. Water from this tank is circulated through the milk cooler by a small pump and returns to the tank to be re-cooled by the block of ice. These outfits are compact, and as only water is used in the coils, the cooler can be easily detached for proper sterilization.

Farmers wishing to electrify their dairies are often restricted in their choice of steam raisers by limitations regarding electric power supply; the capacity of the local transformer often makes the installation of high-powered steam raisers impossible. The alternative is a storage steam raiser which may be of the boiler type, or one employing a block of iron in which temperature is raised sufficiently to produce steam when water is released on it. These storage steam raisers, which consume a limited supply of current over a long period such as six hours, do help in load spreading; and if the heat is built up at night for the usual morning sterilization they are largely free from the inconvenience of morning power cuts.

C.E.E.
C.C.

PROVINCIAL NOTES

DEVELOPMENT OF THE HILL AND MARGINAL LAND OF CORNWALL

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The South-West is particularly equipped by nature for a system of farming in which livestock are of paramount importance. Cornwall is especially so fitted, with its mild moist climate and the consequent ability to grow grass abundantly and cheaply over a long period of the year. The small size of the average farm unit also makes it well suited to livestock farming, for the rearing and management of stock is essentially a personal affair.

Cornwall is a county of approximately 620,000 acres of tillable land and 85,000 acres of rough grazings. On this area are maintained almost 300,000 head of horned stock and 220,000 sheep. (In addition about 100,000 pigs and 2,000,000 poultry and a few horses look for their sustenance to these acres.) By ordinary standards, therefore, the county is already heavily stocked and at first sight it may be difficult to appreciate that there might still be considerable scope for expansion and development. In the areas mainly devoted to dairying and lowland sheep, it is true that expansion in both numbers and quality of livestock will have to be slow. There are, however, considerable areas in the centre and the east, comprising the Bodmin Moor and its surrounding farmlands, where the main enterprise is the rearing of beef stores, dairy replacements and hardy sheep for crossing, and where expansion is not only possible, but essential, if the farmers of the area are to enjoy the relative prosperity of their fellows who engage in producing commodities for direct human consumption.

This is the land to which it is hoped that the Livestock Rearing Act will bring its benefits. It emphasizes the nation's considered conclusion that only by offering financial inducements in the form of grants towards improvement schemes can any appreciable expansion in livestock raising from such areas be expected.

The Bodmin Moor Area

The region under consideration extends to some 40,000 acres of gently rising foothills and uplands between the 500 ft. and 1,500 ft. contours. The granite rocks are overlain by black peaty soils, grading into soils of the Devonian series around the fringes. Rocky outcrops

are not numerous and the natural herbage is of the molinia-sheep's fescue-heather type. Its high rainfall (60-90 inches) makes the whole area largely unsuited to arable farming. Most of the farm units are of between 50 and 150 acres in extent and concentrate on stock-rearing. An interesting feature of the area is that over 20,000 acres consist of open common land subject to rights of common grazing, and on these common grazings those having rights depend largely for summering their store stock.

The past history of this land is one of general depression. Inherently of low fertility, unsuited to the production of milk, butter and eggs, it naturally suffered worst of all in the hard-hit industry that will for many years remember the depression of the 1920s.

Most of the farmers here struggled on, cutting expenditure to a minimum and practising their traditional type of farming. Some turned over to milk production, often with totally unsuitable fixed equipment; others gave up the unequal struggle and left the land. Houses, cottages, buildings and fences were neglected or lapsed into dereliction.

The early war years brought no immediate relief to this land. It was still a problem area—obviously too vast to be neglected, but also obviously not capable of being fitted neatly into any ploughing-up campaign. The enclosed land had to yield a proportion of its acres to the plough in the sheer necessity of making even these holdings as self-supporting as possible. There remained, however, many hundreds of acres, including the common land, which could only make their contribution through increased stock. More stock would need more fodder in winter and more grazing in summer, and the problem therefore resolved itself largely into improving the moorland grazings and increasing the accommodation available for cattle and their fodder during the winter.

Reclamation by W.A.E.C.

In 1942, by agreement with the Commoners, some 2,000 acres were requisitioned by the Minister. Large blocks, totally unequipped, were fenced with posts and wire, cleared of low scrub and gorse, and ploughed. Initial clearing costs were not high, as a very small proportion of the areas chosen for reclamation was covered with bushes or trees.

The soil was inherently short of lime and after ploughing, this deficiency was remedied by the application of an average dressing of 10 tons per acre of Cornish sea sand. (This is a product of the beaches of the north coast of Cornwall, containing 60-80 per cent $CaCO_3$. It is in every way an excellent product, the basis of all sound Cornish farming for generations, and in view of the distance from the recognized sources of lime, most providentially situated.) Pioneer crops were usually rape or potatoes, followed by corn. These were usually excellent crops, but the high autumn rainfall made harvesting difficult, and in the past four years the whole of the land has been put back to grass, to which it is obviously by nature suited.

Seeds mixtures of the Cockle Park type (mostly of commercial strains), generously manured with phosphatic fertilizers, have proved highly productive. Their performance indicates that for this part of the world "manuring and management" take precedence over "mixtures" in importance. The land has yielded heavy crops of hay and has carried considerable numbers of cattle and sheep. This once poor-grade land has proved abundantly capable of not only rearing fine stock but of turning out fat cattle and sheep of good quality in a reasonable period. In 1949 and 1950 over 75 per cent of the fat cattle sold have been graded "A" or higher. When convenient in late years, parts of the grazing have been let for the season and have averaged £4 per acre. In 1950, however, the 504 acres not so let were costed and sales plus outgoing valuation exceeded the initial valuation plus purchases by no less than £10 per acre.

Presumably all this land will be returned to the common grazings after 1952 and the C.A.E.C. and Commoners' Association are now negotiating in the hope that a scheme may be evolved of management and manuring of the reclaimed area with the object of retarding as far as possible the reversion of the pastures once more to scrub.

Observation Plots

Striking as they undoubtedly are, these reclamations have, of course, touched only the fringe of the problem of increasing the productivity of the whole moorland area. From the earliest days of the war it was obvious that other means would need to be explored of grading-up the moorland pastures if they in their turn were to be called upon to produce more store cattle and sheep. The Technical Development Committee of the day therefore laid down on the open moorland a series of simple observation plots to study the following treatments :

(*a*) application of 10 tons per acre of calcareous sand ;

(*b*) as in (*a*) plus drastic surface cultivations ;

(*c*) 10 tons per acre sand plus 10 cwt. per acre basic slag with surface cultivation ;

(*d*) as in (*c*) plus the introduction of cheap seed cleanings of S.48 timothy, S.23 ryegrass and wild white clover.

Appropriate control plots were left.

Response to all treatments was dramatic, particularly as cattle from all over the moorland areas seemed to seek out and congregate upon the plots. Surface roughage was soon eliminated and since the end of the first year the plots have stood out as green oases in the (comparative) desert surrounding. Where seed cleanings were introduced the herbage has changed radically and the S.48 timothy particularly has shown itself to be well adapted to the existing conditions.

Changes in the soil status and the quality of the herbage have been followed through the results of soil analyses and herbage analyses from samples taken each year. Results of the analyses of samples taken in September, 1950, are shown in the following tables :

Table 1

Chemical Analyses of Soil Samples
Mean Result of Soil Analyses at Six Centres

Treatments	pH	Lime Requirement Cwt. CaO	Lime Requirement Cwt. $CaCO_3$	Available (Parts per million) P_2O_5	Available (Parts per million) K_2O
Control plot	4.8	32	1208	7.0	152
Sand only	5.68	17	3000	7.2	160
Sand and cultivation	5.64	15	3460	7.0	135
Sand, slag and cultivation ...	5.56	16	3320	7.0	165
Sand, slag, cultivation and re-seeding	5.78	13	3460	7.0	117

Table 2

Chemical Analyses of Herbage Samples
Mean Results of Analyses at Six Centres

Treatments	Crude Protein per cent	Minerals Expressed as Percentage of Dry CaO	P_2O_5	K_2O
Control plot	10.3	.36	.52	1.24
Sand only	11.73	.62	.482	1.40
Sand and cultivation	11.16	.58	.55	1.40
Sand, slag and cultivation	13.95	.65	.56	1.51
Sand, slag, cultivation and reseeding ...	14.27	.88	.55	1.86

Due, no doubt, to the very heavy stocking which these plots have experienced, there has been a steady rise in the fertility level of the soil throughout the whole series of plots. The differences in fertility level between the plots at the last analysis (Table 1) indicate a marked superiority in the lime status of the treated plots over the control, but show that the P_2O_5 and K_2O levels do not vary appreciably between the various plots. The continuous grazing and deposition of excreta no doubt account for this. Yearly analyses show, in fact, an annual increase in the P_2O_5 and K_2O content of the soils of the whole series.

More striking are the changes in the composition of the herbage of the various plots. Table 2 indicates the considerable increase in the crude portein, lime and potash contents of the improved herbage. From observation, larger quantities of herbage have also been grown on the improved plots, but continuous defoliation makes it almost impossible to quote reliable data on this point.

As a result of the plot observations mentioned above, the commoners have this year been persuaded to co-operate in the widespread sanding and manuring of suitable areas of the moorlands, the scheme being financed by contributions made by the commoners from their hill cattle subsidy.

The dramatic results shown in the first year by the observation plots are not likely to be repeated on the large scale scheme now in hand, but there can be no doubt that even a 10 per cent increase in the quantity and quality of the herbage of the areas being treated will have a more profound effect than any other factor on the stock-carrying capacity of the whole moorland area.

Progress with comprehensive schemes of rehabilitation under the Hill Farming Act, 1946, has been necessarily slow. It is a pre-requisite of the acceptance of any proposed scheme by the Ministry that the occupier shall maintain, or undertake to maintain, a flock of hardy hill sheep. These flocks are so few in number that a strict limit has been thereby imposed upon the progress it has been possible to make with Improvement Schemes. The new Livestock Rearing Act will, it is hoped, sweep away this restriction and allow this vital work to expand. In spite of present limitations no less than 50 per cent of the occupiers who are eligible to benefit have put forward proposals under the Scheme —a considerably higher percentage than in any other county.

It is vital that this work should go ahead. Greater production of much needed store stock from areas such as these can never be put on a stable footing unless, alongside the livestock expansion, provision is made for better amenities, roads, houses for man and beast, and improved grazings and fences.

Many occupiers who have been debarred from taking part in comprehensive improvement schemes because they could not or would not maintain flocks of hardy sheep, have found a partial solution to their problems through the Marginal Production Scheme. In this county the operation of the scheme has been confined largely to assisting in the reclamation of small areas of derelict or semi-derelict land attached to existing holdings. Occupiers in the moorland area have taken advantage of the scheme to bring back under cultivation small areas of the land which, during the inter-war years, were allowed to revert to the natural herbage of molinia, heather and gorse. Many excellent schemes have been completed, usually by clearing, ploughing, liming, manuring and growing pioneer crops of rape before reseeding to grass. The advantages of sowing two crops of rape in successive years before reseeding have been demonstrated many times in the better resultant take of seeds and the closer consolidation of the naturally springy moorland soils.

Improved grazings and the availability of greater quantities of high class fodder for winter conservation are awakening an interest in silage making. Much, however, remains to be done in this connection in an area where the high rainfall renders it almost impossible to make good hay.

Problems for the Future

Land Improvement. The possibilities, then, of this area are considerable. The degree to which it is allowed to make its contribution to the national demand for store stock is a matter which will largely be decided by the amount of capital available for expansion. It must be remembered that we have here a " depressed area " of the pre-war days, with signs everywhere of deteriorated equipment and land, and shortage of money. It must also be remembered that areas such as this have not had the opportunities to recoup and expand their industry, as have the more fertile areas and those suited to the production of commodities for direct human consumption. Capital is needed for repairs and improvement of houses, buildings and fences, and these

naturally will be of little use unless they are accompanied by an increased productivity of the land. Future improvement schemes under the Livestock Rearing Act will, therefore, meet the Ministry's requirements in that they will have to be fully " comprehensive " and include all departments of the farm if they are to be fully effective and achieve the desired increases of livestock. Schemes of various sorts initiated during the war have shed light on the great possibilities of the area.

Livestock Improvement. Problems to be faced in the numerical expansion of cattle and sheep are mainly of a physical nature. There is, for instance, considerable room for expansion in the sheep population—the true hill land of Cornwall makes ideal breeding ground for the Scotch Blackface, Cheviot and other hill breeds, and surplus stock from these flocks is in great demand for crossing into the lower-land flocks. Before, however, the sheep numbers can be expected to expand, problems of fencing and shortage of shepherds have to be overcome. Years of patient attention to breeding must be spent in building up the hill breeds, which are naturally slow to multiply and which must be bred largely in the areas they are to populate.

Another very real obstacle which has only recently been overcome is that of the cobalt deficiency which has retarded livestock expansion in the past and has led to the area becoming well-known as one of the " pining " districts of the British Isles. Cobalt deficiency, being apparently less severe and obvious in cattle than sheep has, no doubt, been partly responsible for the predominance of cattle over sheep on the moorlands. Patterson [1] carried out some of his original research on flocks on the Bodmin Moor and was able through his discovery of the cause of " pining " to offer a complete prevention and cure for this fatal disease. Established flockmasters already make a practice of regularly dosing sheep with cobalt salts (often incorporated in a vermifuge) or of applying cobalt to the grazings. Strips are treated in each field with 2 lb. per acre cobalt chloride, usually mixed previously with inorganic fertilizers or sand. There has already been talk of treating large areas of inaccessible land with cobalt by aeroplane, but this is, perhaps, of the future.

If real progress is to be made in this area greater attention must be paid to breeding and feeding policies for both cattle and sheep. Expansion in numbers alone, without greater attention to herd and flock management, can bring no credit to this area and very little profit to its farms. It is most difficult to pursue a constructive breeding policy in areas such as these where common grazings are so widely used, and where, unlike many other hill areas, the hill land is not divided among herd and flock-owners. Cattle and sheep stray almost at will over large tracts of country and this has meant in the past that mating has been haphazard. The Control of Rams Regulations, 1950, has been welcomed and during its first year of operation has given promise of important results. The inspection for suitability of rams turned on the open moor is a definite step forward, and the prohibition of rams from the moor during the months of August, September and October will eliminate the old

problem of hill ewes lambing in the spring before grazing is available to keep up their milk supply.

Roaming bulls are also a problem. Many young heifers are bulled at too tender an age and constructive breeding in the more progressive herds is made very difficult. The commoners themselves are at present actively engaged in the solution of this problem. They have proposed a scheme under the Commons Act, 1908, which would effectively prohibit the access at all times of bulls to the common grazings. The importance of such a step forward cannot be over-emphasized and it is greatly to the credit of the farmers of the area that they themselves have put forward the scheme. If the present proposals are adopted it will be necessary for commoners to remove their cows from the common grazings for bulling and this will make possible a much closer attention to the selection of suitable bulls for particular herds and the beginning of a much-needed improvement in the breeding of cattle of this area.

Obviously much remains to be done. Some progress has, however, been made towards the development of the Bodmin Moor as a stock-rearing area and the problems yet to be met are understood. The impetus needed to hasten the development will come, it is hoped, from recent legislation which will make all-important capital available to the moorland men who by inclination and up-bringing are otherwise eminently suited to the task of expanding their production of store cattle and sheep.

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